AMENDMENTS TO THE SPECIFICATION

Please amend the paragraph on page 6, line 6, to line 10, as follows:

As described above, when a mode dispersion occurs which is a phenomenon ~~reduction~~ in which the phase velocity or the group velocity differs among the modes, the signal beam cannot be transmitted while the intensity distribution of the incident beam is maintained to the exit side.

Please amend the paragraph on page 7, line 15, to page 8, line 2, as follows:

Moreover, a technology is known in which the optical waveguide (sheet-form optical transmission line) is provided with a mirror for perpendicularly bending the optical axis of the signal beam and the optical waveguide is coupled to the outside (FIGs. 1 and 2 of Document (16)~~2~~). In the optical waveguide described in Document (16), the signal beam incident from a direction perpendicular to the transmission direction is bent by a mirror disposed at 45 degrees from the signal beam transmission direction and is incident on the optical waveguide. Moreover, the signal beam transmitted through the optical waveguide is bent by a mirror disposed at 45 degrees from the signal beam transmission direction and exits in a direction perpendicular to the transmission direction (see FIGs. 1 and 2 of Document (16)).

Please amend the paragraph on page 29, line 11, to line 16, as follows:

Preferably, further, the optical transmission line is made of polysilane. Moreover, preferably, further, ~~an optical device manufacturing method according to claim 35, wherein~~ the optical transmission line is made of polysilane, and the refractive index distribution is provided by an oxygen concentration distribution when the polysilane is cured.

Please amend the paragraph on page 39, line 17, to page 40, line 2, as follows:

Preferably, ~~an optical device according to claim 49, wherein~~ the refractive index modulating means

is capable of changing the refractive index distribution of the second multi-mode partial optical transmission line,

in the second condition, makes the refractive index distributions of the first and second multi-mode partial optical transmission lines the same as each other, and

in the first condition, makes a highest refractive index of the second multi-mode partial optical transmission line lower than a highest refractive index of the first multi-mode optical transmission line.

Please amend the paragraph on page 113, line 15, to page 114, line 6, as follows:

FIG. 5 is a perspective view showing the general outline of a two-signal cross sheet bus which is an optical device according to a fourth embodiment of the present invention. The optical device according to the fourth embodiment comprises as a main element a graded index slab waveguide 501 that transmits beams. The graded index slab waveguide 501 is, as shown in FIG. 5, a sheet-form multi-mode optical transmission line that extends parallel to the x-z plane. The graded index slab waveguide 501 has a distribution such that the highest refractive index n_{max} is provided at the center in the direction of the thickness and the refractive index does not increase with distance from the center. The graded index slab waveguide 501 has a uniform refractive index in the direction of the width and has no refractive index distribution. The optical device according to the <u>fourth</u> ~~fifth~~ embodiment is provided with an array E/O converter 532, an input electric line (bus) 333, and an array O/E converter 536 and an output electric line (bus) 337.

Please amend the paragraph on page 117, line 13, to page 118, line 11, as follows:

FIG. 6 is a perspective view showing the general outline of an eight-signal cross sheet bus which is an optical device according to a modification of the fourth embodiment of the present invention. The schematic structure of the optical device of the modification is the same as that of the previously-described two-signal straight sheet bus. The optical device of the modification is provided with a graded index slab waveguide 601, an array E/O converter 632, an input electric line (bus) 333, an array O/E converter 636 and an output electric line (bus) 337. The array E/O converter 632 has generally the same structure as the array E/O converter 532 of the two-signal straight sheet bus; however, it is different in that a light emitting portion group 646 comprising eight light emitting portions is formed instead of the first light emitting portion 530 and the second light emitting portion 531. Moreover, the array O/E converter 636 has generally the same structure as the array O/E converter 536 of the two-signal straight sheet bus; however, it is different in that a light receiving portion group 647 comprising eight light

receiving portions is formed instead of the first light receiving portion 534 and the second light receiving portion 535. The light emitting portions included in the light emitting portion group 646 ~~640~~ are all disposed in positions symmetrical to the light receiving portions included in the light receiving portion group 647 with respect to the center in the direction of the width.

Please amend the paragraph on page 119, line 7, to line 16, as follows:

While examples of the two-signal cross sheet bus and the eight-signal cross sheet bus are shown in the fourth ~~third~~ embodiment, generally, an N-signal cross sheet bus (N=1, 2, 3, ...) can be similarly designed. In this case, by making a number, N, of incident beams incident on given positions of the incident surface of the graded index slab waveguide having a slab length L which is substantially an odd multiple of the following expression, a number, N, of exiting beams can be obtained from positions the same as the positions symmetrical with respect to the center, in the direction of the width, of the exit surface.

Please amend the paragraph on page 135, line 20, to page 136, line 2, as follows:

FIG. 20B is a perspective view showing the general outline of a both side control type optical switch which is an optical device according to a third modification of the sixth embodiment of the present invention. The third ~~second~~ modification of the sixth embodiment is an optical device comprising a combination of the previously-described first modification and second modification of the sixth embodiment. The same reference numerals indicate the same elements.

Please amend the paragraph on page 137, line 12, to page 138, line 2, as follows:

The first array O/E converter 905 has a first light receiving portion group 903 comprising eight light receiving portions provided so as to be opposed to exit portions corresponding to the first graded index slab partial waveguides 801a of the optical switches. Moreover, the first array O/E converter 905 is connected to the first output signal line 908. The second array O/E converter 906 has a second light receiving portion group 904 comprising eight light receiving portions provided so as to be opposed to exit portions corresponding to the second graded index slab partial waveguides 801b of the optical switches. Moreover, the second array O/E converter 906 is connected to the second output signal line 908. In this example, the optical device is

structured so that when the temperature controller is ON, the exiting beam exits from the side of the first graded index slab partial waveguide and when the temperature controller is ~~ON~~ OFF, the exiting beam exits from the side of the second ~~first~~ graded index slab partial waveguide.

Please amend the paragraph on page 143, line 5, to page 144, line 10, as follows:

The first beam 1018 emitted from the first light emitting portion 1014 is incident on the graded index slab waveguide 1001 through the incident surface 1002 to be transmitted. The first beam 1018 forms, according to the self-imaging principle, an image having the same profile as that when the beam is incident in the vicinity of the second light receiving portion 1017. By this, the first beam 1014 is outputted from the second surface 1003 to the second light receiving portion 1017. The second light receiving portion 1017 outputs an electric signal corresponding to the received first beam 1018. The outputted electric signal is outputted to the outside from the second output electric line 1013. On the other hand, the second beam 1019 emitted from the second light emitting portion 1015 is incident on the graded index slab waveguide 1001 through the second surface 1003 to be transmitted. The second beam 1019 forms, according to the self-imaging principle, an image having the same profile as that when the beam is incident in the vicinity of the first light receiving portion 1016. By this, the second beam 1019 is outputted from the first surface 1002 to the first light receiving portion 1016. The first light receiving portion 1016 outputs an electric signal corresponding to the received second beam 1019. ~~The first light receiving portion 1016 outputs an electric signal corresponding to the received second beam 1019.~~ The outputted electric signals are outputted to the outside from the first output electric line 1012. As described above, since the MMI is reversible irrespective of the beam transmission direction, the MMI can be used in both directions. Consequently, it is unnecessary to provide separate optical waveguides to straightly transmit two signal beams in both directions, so that two signal beams can be independently transmitted in both directions with one graded index slab waveguide 1001.

Please amend the paragraph on page 146, line 1, to line 13, as follows:

The first light emitting portion group 1114 makes a first beam 1121 to a fourth beam 1124, which are four signal beams all having the same wavelength, independently incident on the graded index slab waveguide 1101 ~~1121~~ through a first surface 1102 based on the external

electric signal inputted from the first input electric line 1010. The graded index slab waveguide 1101 transmits the first beam 1121 to the fourth beam 1124. The first beam 1121 to the fourth beam 1124 exit from a second surface 1103 and are received by the light receiving portions, whose positions in the direction of the width are the same, of the second light receiving portion group 1117 like in the case of the graded index slab waveguide 1001. The received signals are outputted to the outside by the second output electric line 1013.

Please amend the paragraph on page 151, line 20, to page 152, line 23, as follows:

The first beam 1218 emitted from the first light emitting portion 1214 is incident on the graded index slab waveguide 1201 through the first surface 1202 to be transmitted. The first beam 1218 forms, according to the self-imaging principle, an image having the same profile as that when the beam is incident in the vicinity of the second light receiving portion 1217. By this, the first beam 1218 is outputted from the second surface 1203 to the second light receiving portion 1217, and is outputted to the outside from the second output electric line 1011. On the other hand, the second beam 1219 emitted from the second light emitting portion 1215 is incident on the graded index slab waveguide 1201 through the second surface 1203 to be transmitted. The second beam 1219 forms, according to the self-imaging principle, an image having the same profile as that when the beam is incident in the vicinity of the first light receiving portion 1216. By this, the second beam 1219 is outputted from the first surface 1202 to the first light receiving portion 1216. The first light receiving portion 1216 outputs an electric signal corresponding to the received second beam 1219. ~~The first light receiving portion 1216 outputs an electric signal corresponding to the received second beam 1219.~~ The outputted electric signals are outputted to the outside from the first output electric line 1012. As described above, since the MMI is reversible irrespective of the beam transmission direction, the MMI can be used in both directions. Consequently, it is unnecessary to provide separate optical waveguides to transmit two signal beams so as to cross each other in both directions, so that two signal beams can be independently transmitted in both directions with one graded index slab waveguide 1201.

Please amend the paragraph on page 154, line 5, to page 155, line 8, as follows:

In the first array E/O converter 1302, eight light emitting portions disposed on one end surface (left side of the figure) of the two-way straight sheet buses are formed into an array. In the first array O/E converter 1303, eight light receiving portions disposed on one end surface (left side of the figure) of the two-way straight sheet buses are formed into an array. The first array E/O converter 1302 and the first array O/E converter 1303 are disposed so as to adjoin each other. In the second array E/O converter 1305, eight light emitting portions disposed on the other end surface (right side of the figure) of the two-way straight sheet buses are formed into an array. In the second array O/E converter 1304, eight light receiving portions disposed on one end surface (~~right and~~ left side of the figure) of the two-way straight sheet buses are formed into an array. The second array E/O converter 1305 and the second array O/E converter 1304 are disposed so as to adjoin each other. The light emitting portions of the first array E/O converter 1302 and the light receiving portions of the second array O/E converter 1304 are disposed so as to be opposed to each other with the two-way straight sheet buses in between. The light emitting portions of the second array E/O converter 1305 and the light receiving portions of the second array O/E converter 1303 are disposed so as to be opposed to each other with the two-way straight sheet buses in between. The first array E/O converter 1302 is connected to the first input electric line 1306. The second array E/O converter 1305 is connected to the second input electric line 1308. The first array O/E converter 1303 is connected to the first output electric line 1307. The second array O/E converter 1304 is connected to the second output electric line 1309.

Please amend the paragraph on page 159, line 7, to page 160, line 7, as follows:

The incident surface 2102 is opposed to an incident portion (not shown) that makes a multiplex incident beam 2107 comprising multiplexed beams of two different wavelengths (a wavelength 1.30 μm and a wavelength 1.55 μm) incident on a position a predetermined distance away from the center in the direction of the width. The exit surface 2103 is opposed to an exit portion (not shown) that receives two exiting beams 2108 and 2109 of different wavelengths that exit from positions symmetrical to each other with respect to the center in the direction of the width. The incident portion makes the multiplex incident beam 2107 incident on a position a predetermined distance away from the center, in the direction of the width, of the incident surface 2102. The multiplex incident beam 2107 is transmitted inside the graded index slab

waveguide ~~101~~ 2101. Inside the graded index slab waveguide 2101, the multiplex incident beam 2107 is demultiplexed into two beams in accordance with the wavelength according to the self-imaging principle of the multi-mode interference described later, exits as the two exiting beams 2108 and 2109 having different wavelengths (a wavelength 1.30 μm and a wavelength 1.55 μm) from positions away from each other in the direction of the width of the exit surface 2103, and reaches the exit portion. The slab length L of the graded index slab waveguide 2101 is an optical path length where the phase difference between the light quantity movement of the wavelength 1.30 μm and the light quantity movement of the wavelength 1.55 μm is opposite phase (that is, an integral multiple of π).

Please amend the paragraph on page 172, line 2, to line 10, as follows:

The second graded index slab waveguide 2302 and the third graded index slab waveguide 2302 are the same as the cross sheet bus according to the fourth embodiment. That is, the slab lengths L_2 of the second graded index slab waveguide 2302 ~~2301~~ and the third graded index slab waveguide 2303 are a function of the basic mode width W_0 in the direction of the width, the effective refractive index n_0 of the 0th-order mode beam excited in the direction of the width and the wavelength λ of the incident beam, and are both approximately $4 \times n_0 \times W_0^2/\lambda$.

Please amend the paragraph on page 176, line 17, to page 177, line 1, as follows:

FIG. 25 is a top view showing a relevant part of an optical device for increasing the distance between signal beams according to a second modification of the thirteenth embodiment of the present invention. As shown in FIG. ~~24~~ 25, the optical device according to the second modification of the thirteenth embodiment is provided with a plurality of graded index slab waveguides disposed so that the incident positions are shifted from one another in the direction of the length. The graded index slab waveguides are each the same as the graded index slab waveguide described in the case of the cross sheet bus according to the fourth embodiment.

Please amend the paragraph on page 186, line 14, to line 21, as follows:

FIG. 29 is a perspective view showing the general outline of the structure of an optical device according to a third modification of the fourteenth embodiment of the present invention. Since the optical device according to the third ~~second~~ modification of the fourteenth embodiment

has substantially the same structure as the optical device according to the first modification of the fourteenth embodiment, only different parts will be described. Moreover, the same reference numerals indicate the same elements.

Please amend the paragraph on page 191, line 8, to line 14, as follows:

After the polysilane 3103 is cured, parts corresponding to the incident and exit end surfaces are cut into the shape of the graded index slab waveguide 3110 (fourth step). In this manner, the graded index slab waveguide can be manufactured. The transparent forming die 3102 after the cutting can be used as a substrate 3105 of the graded index slab waveguide 3110 as it is. Needless to say, the substrate 3105 ~~3005~~ may be removed.

Please amend the paragraph on page 192, line 8, to line 23, as follows:

FIG. 32 is an explanatory view explaining the mechanism of the refractive index distribution using polysilane. As mentioned previously, polysilane is changed into a siloxane structure (FIG. ~~32(e)~~ 32E) having a lower refractive index by the oxidization, at the time of curing, that occurs due to ultraviolet exposure or heat treatment. For this reason, a refractive index distribution can be provided by controlling the ratio between the polysilane structure (FIG. ~~32(d)~~ 32D) part that is not oxidized and the siloxiane structure part that occurs due to oxidization. As is apparent from the figures, polysilane is disposed in an oxygen atmosphere (FIG. 32A) and either ultraviolet exposure or heating is performed (FIG. 32B), whereby a mold is obtained in which the ratio of the polysilane structure is high in the central portion where the oxygen concentration is low and the ratio of the siloxane structure is high in the surface part where the oxygen concentration is high (FIG. 32C).

Please amend the paragraph on page 195, line 19, to page 196, line 1, as follows:

Then, in FIG. 35, an assembly die 3501 is prepared in which a concave portion 3502 corresponding to the graded index slab waveguide ~~3401~~ 3410, a V-groove 3503 for positioning an incident side optical fiber 3520 and a V-groove 3504 for positioning exit side optical fibers 3530 are previously formed. By disposing the graded index slab waveguide ~~3401~~ 3410, the incident side optical fiber 3520 and the exit side optical fiber 3530 in the assembly die 3501, the optical device can be manufactured.

Please amend the paragraph on page 203, line 1, to line 10, as follows:

FIG. 37 is a cross-sectional view of a part, where the signal beam is transmitted, of the multi-mode interference 1×2 splitter 5100 according to the fifteenth embodiment of the present invention. FIG. 37 ~~2~~ is a cross-sectional view in which the D-H side of the cross section, taken on a plane including the C-D-G-H plane in FIG. 36A, of the sheet-form optical transmission line 5101 and the incident portion 5104 and the E-I side of the cross section, taken on a plane including the E-F-I-J plane in FIG. 36A, of the sheet-form optical transmission line 5101 and the exit portion 5105 are connected together.

Please amend the paragraph on page 208, line 2, to line 10, as follows:

The physical optical path length, on the optical path A, from the position corresponding to the position where the optical path B reaches the reflecting surface 5102 to the position where the optical path A reaches the reflecting surface 5102 is defined as ~~LA1~~ L1A. The physical optical path length, on the optical path B, from the position where the optical path B reaches the reflecting surface 5102 to the position corresponding to the position where the optical path A reaches the reflecting surface 5102 is defined as ~~LB1~~ L1B.

Please amend the paragraph on page 210, line 25, to page 211, line 4, as follows:

Letting the refractive index distribution constant be g and the refractive index at the central portion 5101a be n_{max}, the refractive index distribution in the y-direction is defined by the quadratic function shown by the following (Expression ~~2~~ 9):

$$n(y) = n_{max}\left(1 - \frac{g^2 y^2}{2}\right) \qquad \text{(Expression 9)}$$

Please amend the paragraph on page 229, line 15, to page 230, line 2, as follows:

Moreover, in the optical device according to the seventeenth embodiment, the above-described sheet-form optical transmission line includes the reflecting surface 5102 and the reflecting surface 5103, and the physical optical path length between the reflecting surface 5102 ~~102~~ and the reflecting surface 5103 ~~103~~ at the central portion 5101a ~~101a~~ is equal to (j/2) times (j=0,1,2,3,...) the period of meandering of the optical path along which the signal beam is transmitted while meandering based on the refractive index distribution. Moreover, in the

optical device according to the seventeenth embodiment, the signal beam is condensed into a line parallel to the x-direction orthogonal to both the y-direction and the z-direction at the central portion, where the thickness in the first direction is half, of the optical transmission line.

Please amend the paragraph on page 233, line 19, to page 234, line 1, as follows:

FIG. 41B is a cross-sectional view of a part, where the signal beam is transmitted, of the multi-mode interference 1×2 splitter 5500 according to the nineteenth embodiment of the present invention. FIG. 41B is a cross-sectional view of the multi-mode interference 1×2 splitter 5500 taken on the same place as that in the case of the multi-mode interference 1×2 splitter 5100 according to the fifteenth embodiment shown in FIG. 36 ~~1~~ and FIG. ~~2~~ 37. In the figure, the refractive index distribution is omitted.

Please amend the paragraph on page 234, line 7, to line 14, as follows:

The incident portion 5504 is structured so that the optical axis of the signal beam incident on the sheet-form optical transmission line 5501 ~~5401~~ is not parallel to the z-direction but is at a predetermined acute angle with respect thereto. Moreover, the exit portion 5505 is structured so that the optical axis of the signal beam exiting from the sheet-form optical transmission line 5501 is not parallel to the z-direction but is at a predetermined acute angle with respect thereto.

Please amend the paragraph on page 236, line 19, to page 237, line 4, as follows:

FIG. 42A is a cross-sectional view of a part, where the signal beam is transmitted, of a multi-mode interference 1×2 splitter 5600 according to a twentieth embodiment of the present invention. In the twentieth embodiment, descriptions of the same parts as those of the fifteenth embodiment are omitted and only different parts will be described. The multi-mode interference 1×2 splitter 5600 according to the twentieth embodiment has approximately the same structure as the multi-mode interference 1×2 splitter 5100 ~~100~~ shown in FIG. 36, and is different only in that a structure corresponding to the exit portion is not provided. In the figure, the refractive index distribution is omitted.

Please amend the paragraph on page 237, line 19, to page 238, line 7, as follows:

FIG. 42B is a cross-sectional view of a part, where the signal beam is transmitted, of a multi-mode interference 1×2 splitter 5700 according to a twenty-first embodiment of the present invention. In the twenty-first embodiment, descriptions of the same parts as those of the fifteenth embodiment are omitted and only different parts will be described. The multi-mode interference 1×2 splitter 5700 according to the twenty-first embodiment has approximately the same structure as the multi-mode interference 1×2 splitter 5100 shown in FIG.~~1~~ 36, and is different only in that a structure corresponding to the incident portion is not provided. In the figure, the refractive index distribution is omitted.

Please amend the paragraph on page 242, line 13, to line 21, as follows:

In the sheet-form optical transmission line 5901, the optical path length difference generating portions are the following four surfaces: the reflecting surface ~~5102~~ 5103, the reflecting surface 5813, the reflecting surface 5819 and the reflecting surface 5103. Therefore, by making the sum of the differences in optical path length between the optical path A and the optical path B caused at the four reflecting surfaces an integral multiple of the signal beam wavelength, the overall phase difference between the optical path A and the optical path B can be made zero.

Please amend the paragraph on page 243, line 15, to line 22, as follows:

Moreover, while the light receiving element 5111 and the light receiving element 5112 are photodiodes in the embodiments, they may be different elements such as phototransistors. Moreover, the incident portion of a different optical transmission line for transmitting a signal beam may be disposed in the positions of the light receiving point 5112a of the light receiving element 5111 ~~and the light receiving point 5112a of the light receiving element~~.